SECTION 16

WALLS AND ABUTMENTS, DESIGN CRITERIA

1.16.1 Equivalent Fluid Pressure ..... 5.5 kilonewtons per cubic meter

1.16.2 Dead Load of Soil ..... 18.9 kilonewtons per cubic meter

1.16.3 Dead Load of Concrete ..... 23.6 kilonewtons per cubic meter

1.16.4 fc' ..... 21 megapascals

1.16.5 fc ..... 8.4 megapascals

1.16.6 fs (Grade 420 Rebars) ..... 165 megapascals

1.16.7 Surcharge for Level Backfill ..... 0.6 meters

1.16.8 Sloping Surcharge ..... Variable - Use acceptable method such as Coulomb or Rankine's method.

1.16.9 Sliding Factor of Safety 1.5

1.16.10 Overturn Factor of Safety 2

1.16.11 Vertical Load Per Meter of Approach Slab Reacting on Abutment Backwall:

Treat Approach Slab as a 7.5 meters simple span beam.

1.16.12 Horizontal Thrust Force for Approach Slab Resting on Abutment Backwall: None

1.16.13 Surcharge due to Temporary Construction Equipment and any temporary overstress permitted (this is used for extraordinary conditions but shall not exceed the following):

Variable: 50% maximum overstress for structural components; 25% overstress for foundations.

1.16.14 Lateral Loads on Piles

The lateral load design capacity of piles is a function of the flexural stiffness of the shaft, the stiffness of the bearing soil in the upper portion of the pile and the degree of fixity in the pile head. It is also related to the amount of lateral deflection permitted, method of placement and pile group action.

1. The following allowable forces should be used for determining the lateral resistance of piles, if minimal site specific information exists regarding the foundation soil parameters in accordance with

AASHTO Subsection 4.3. However, if more extensive subsurface exploration is to be performed, then analytical design methods may be used, as stated in part (b) below.

Pile Type	Lateral Resistance
310 millimeters Nominal Steel-H	35.6 kilonewtons
310 millimeters Timber	17.8 kilonewtons
310 millimeters Cast In Place Concrete	26.7 kilonewtons
310 millimeters Precast Concrete	26.7 kilonewtons

The values above are applicable only for the pile types specified and if the upper limit of the pile is in compact, granular material.

2. In lieu of the above values, a detailed analytical analysis will be permitted under the following conditions:

   a. The chosen analytical method shall conform to those accepted and approved by the FHWA (refer to the FHWA Manual on Design and Construction of Driven Pile Foundations).

   b. Analytical methods can only be used in cases where extensive soil investigation has been performed within the footing area.

   c. Tolerable movement criteria for footings is in accordance with AASHTO Subsections 4.4.7.2.5 and 4.5.12. Special consideration shall be given to footing movements for continuous bridges.

3. When piles are battered, the horizontal component due to the batter of the pile is added to the lateral resistance.

1.16.15 Horizontal load taken by pile in lieu of or in addition to use of batter:

Same as lateral loads on piles 1.16.14. 1. above.

1.16.16 Temperature and Distribution Reinforcement:

13 at 300 millimeters spaced horizontally in the exposed face of walls. Vertical bars in the exposed faces of walls shall be determined by design. The minimum reinforcement shall be # 13 at 450 millimeters.

Reference Guide Sheet Plates 3.3-1, 3.3-2 and 3.4-1 for more information.

1.16.17 Top heel steel is designed to support all superimposed material plus dead load of footing without reduction from minimum upward soil pressure acting beneath the heel.

1.16.18 Passive forces are to be disregarded for all factors of footing and wall design.

1.16.19 Minimum footing thickness shall be 600 millimeters (add 300 millimeters if piles are used).

In order to prevent damage from frost heave, footings shall be founded at an elevation that is 1.25 meters below the existing ground line. Also, refer to Section 46 of this Manual for guidance concerning scour considerations.

1.16.20 The designer shall verify the need for batter in walls under 3 meters. Walls over 3 meters shall have a minimum batter of 12:1. The wall height shall be measured from the top of the footing at the rear face of the stem to the top of the wall.

1.16.21 Rear face of abutments shall be plumb.

1.16.22 Reference AASHTO Table 5.5.2B for Guidance in selecting friction factor coefficients for various soil types. These values should be utilized unless otherwise established by laboratory tests.

Adhesion values for cohesive soils shall range from 4.8 kPa to 57.5 kPa and shall be verified by laboratory or field tests.

1.16.23 Resultant Center of Pressure

1. When the foundation is on soil, the resultant shall be within the middle third of the footing.

2. When footings are founded on rock, the resultant may fall within the middle half, provided the factor of safety against overturning is adhered to.

1.16.24 Toe design based upon cantilever design with earth pressure acting up and dead load of concrete acting down.

1.16.25 Material for steel H-piles shall conform to AASHTO M270/M 270M, Grade 250. Steel H-piles are for use in a marine environment shall conform to AASHTO M270/M270M Grade 345 and shall be coated with a 406 micrometer application of coal tar epoxy as per SSPC Paint Specification 16.

1.16.26 Pile Capacities:

1. **Timber Piles** - For round timber piles, the maximum allowable working stress shall not exceed the values listed in AASHTO Table 4.5.7.3A.

   a. Bearing Piles - Structural capacity shall be equal to the allowable working stress multiplied by the pile tip area.

b. Friction Piles - Structural capacity shall be based on the allowable working stress multiplied by the critical pile section area.

Timber piles should not be used where seismic design considerations are critical.

2. **Cast-in-Place Concrete Filled Steel Pipe Piles** - The maximum allowable stress shall not exceed 0.25 Fy + 0.40 f'c applied over the cross sectional area of the steel pipe and on the gross cross sectional area of the concrete respectively.

3. **Precast Concrete Piles** - The maximum allowable stress shall not exceed 0.33 f'c over the cross sectional area of the concrete. For tapered piles, the tip area should be used in determining the allowable stress for bearing piles, and the critical section should be used in determining the allowable stress for friction piles.

4. **Prestressed Concrete Piles** - For piles fully embedded in soils providing lateral support, the maximum allowable stress shall not exceed 0.33 f'c - 0.27 f_{pe} on the cross-sectional area of the concrete, where f_{pe} represents the extreme fiber concrete compressive stress due to prestressing after all losses.

5. **Steel H-Pile and Unfilled Steel Pipe Piles** - The maximum allowable stress in all cases shall not exceed 0.25 Fy over the cross-sectional area of the pile, not including the area of any tip reinforcement.

Where pile damage or deterioration could occur for any of the above stated pile types, the designer shall utilize a lower stress level than the maximum permitted in AASHTO in accordance with AASHTO Subsections 4.5.7 and 4.5.14.

The Ultimate Pile capacity that is required during driving shall be shown on the Contract Plans. The Ultimate Pile Capacity should include the pile design load times a factor of safety and the frictional driving resistance of any soil layers that are unsuitable for load bearing.

Examples of soil layers that are unsuitable for load bearing would be:

1. Layers that are subject to future scour or erosion.
2. Layers that are subject to strength loss due to earthquakes.

3. Layers that will settle due to placement of future loads or due to existing loads. The settlement could result from the layers' compressibility or the compressibility of underlying layers.

This capacity should be used to develop driving criteria so that the driving resistance of unsuitable soil layers is not included in the permanent Ultimate Pile Capacity.

When a Minimum Pile Tip Elevation is specified, and the maximum soil resistance that is to be overcome is greater than the Ultimate Pile capacity, the maximum soil resistance should be shown on the plans.

1.16.27 Additional conditions to consider for stability of the structure should be checked in terms of:

1. Maximum acceptable post construction settlement.

2. Foundation soil's stabilization for minimum residual settlement.

3. Overall earth mass stability of the foundation soils and/or embankment supporting the structure.

4. Consideration of the foundation soils in the selection of the pile type and size.

5. Consideration of soil characteristics on the post construction effect on pile foundations (drag and additional lateral pressure).

1.16.28 The foregoing design criteria is intended for "typical" reinforced concrete walls with conventional heights and wall sections, in which the designer has an unrestricted ability to proportion the toe and heel dimensions of the footing.

It is recognized that justification for exceptions to these criteria may be offered where certain combinations of conditions are present.